

FUNCTIONAL EXERCISE TRAINING WITH THE TRX SUSPENSION TRAINER IN A
DYSFUNCTIONAL, ELDERLY POPULATION

A Thesis
by
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Abstract

FUNCTIONAL EXERCISE TRAINING WITH THE TRX SUSPENSION TRAINER IN A DYSFUNCTIONAL, ELDERLY POPULATION

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Sarcopenia, the decrease in muscle strength due to the aging process, can lead to impairment in the neuromuscular system, falls and injury, decreased functionality in activities of daily living and decreased independence in the elderly population. Research has shown that resistance exercise training can help to slow, stop, and possibly reverse the process of sarcopenia.

Less research has focused on functional training, or task-specific strength training used to improve functionality in activities of daily living. Functional training has been shown to be effective in improving ability and time in completing activities of daily living in an elderly population and that it may be more effective than resistance training alone.

Much of the research done on using resistance exercise training to improve functionality has been done using traditional free weights and weight machines in a functional, independent elderly population. The dysfunctional, institutionalized elderly population is most in need of easily accessible, effective, and safe methods of

resistance exercise training to improve functionality in activities of daily living. The TRX suspension trainer is a unique modality of exercise that consists of two straps and handles that allow for the use of one's own body weight as resistance and can be easily transported and used in several environments. Therefore, the purpose of this study was to determine if a functional exercise training program, using the TRX suspension system, would be effective in improving functionality in a dysfunctional, institutionalized elderly population.

Subjects ($n=3$) performed an 8-week, progressive functional exercise training program that included exercises that mimic activities of daily living, using the TRX suspension system. Subjects were tested before exercise began, after 4 weeks of exercise, and after 8 weeks of exercise with the Berg Balance Scale, Timed Up and Go Test, Five-Timed Sit-to-Stand Test, Handgrip Strength assessment, and the SF-36 Survey. There was a significant change from 4-week- to post-testing in the sit-to-stand assessment in the Berg Balance Scale. Although only one outcome measure was found to be statistically significant, there were small, but clinically significant improvements in functionality of activities of daily living, and therefore, in quality of life for the participants.

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Dedication

This thesis is dedicated to my mother, Debbie Kosmata. Without you, I never would have gotten this far.

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Chapter 1. Introduction

Falls were the foremost cause of accidental death in 2007 in adults aged 65 and older (Henry-Sanchez, Kurichi, Xie, Pan, & Stineman, 2012). Furthermore, falls that don't lead to death or serious debilitating injury cause increased fear, decreased mobility, deconditioning, and decreased functionality in activities of daily living (ADLs) which can contribute to more falls in older adults (Henry-Sanchez et al., 2012). Approximately 20-30% of the elderly population report debilitating in activities of daily living and mobility (Topinkova, 2008). Previous studies have demonstrated that balance and strength deficits contribute to disability in ADLs (Vermeulen, Neyens, van Rossum, Spreeuwenberg, & de Witte, 2011).

As adults age, there is a decrease in functionality of ADLs and independence, both of which are directly related to physical fitness (Garatachea & Lucia, 2012). Many factors can lead to decreases in functionality, one of which is sarcopenia (Jang & Van Remmen, 2011). Sarcopenia is the loss of muscle mass and strength associated with the aging process (Muhlberg & Sieber, 2004; Yarasheski, 2003). The following futile cycle demonstrates the detrimental effects sarcopenia has on the aging population: Neuromuscular deficiency → Sarcopenia → Fall and Injury → Hospitalization and Immobilization → further Sarcopenia (Muhlberg & Sieber, 2004). Sarcopenia leads to problems with mobility and balance, which impairs gait performance and causes balance disorders (Muhlberg & Sieber, 2004). Difficulty with mobility can lead to more falls, decreases in functionality, disability, and death (Jang & Van Remmen, 2011). Resistance exercise is a potential means to prevent, stop, and reverse the futile cycle of sarcopenia.

Less than 10% of the elderly population take part in resistance exercise (Clemson et al., 2012). Muscle loss, specifically in the lower body can increase the risk of falls (Yarasheski, 2003). Resistance exercise training has proven effective in halting, treating, and preventing the negative consequences of sarcopenia (Greenlund & Nair, 2003; Johnston, De Lisio, & Parise, 2007; Muhlberg & Sieber, 2004). Furthermore, exercise programs consisting of balance and resistance training components have been shown to reduce the number of falls in the elderly (Sherrington et al., 2008). Less is known regarding whether exercise programs using resistance and balance training can improve physical function and performance of ADLs in the elderly.

Functional training is task-specific strength training, or a type of exercise training that focuses on improving ADLs by training the muscles essential for the ADLs or performing motions required to perform the ADLs. Few studies have focused on functional training in an elderly population. Alexander et al. (2001) used a sit-to-stand (STS) test as a measure of functionality and created an exercise regimen that contained movements used in the STS action. The training program consisted of repeating the motions of the STS action, with and/or without the arms of the chair. The training program significantly improved STS time (Alexander et al., 2001); suggesting that functional training programs, consisting of mimicking ADLs, can improve physical function in the elderly (Alexander et al., 2001).

The STS action is an essential ADL that is often used to assess physical function in elderly adults (Lord, Murray, Chapman, Munro, & Tiedemann, 2002). Successful performance of the STS action requires strength, balance, and proprioception. A slower STS time is correlated with decreased balance and mobility, and may predict fall risk and disability (Lord et al., 2002). Difficulty with successfully completing the STS action can

significantly limit physical function, which can lead to loss of independence, institutionalization (Schultz, Alexander, & Ashton-Miller, 1992), and earlier mortality (Henry-Sanchez et al., 2012; Janssen, Bussmann, & Stam, 2002).

Traditional strength, power, and balance and proprioception training programs have been thoroughly examined in elderly populations; however, fewer studies have focused on functional training as a way to improve functionality in elderly. Furthermore, most studies that focus on functionality include independent, elderly people as subjects. The dysfunctional elderly population, those individuals who are unable to or those who have limited functionality in performing ADLs independently, or have musculoskeletal disorders (e.g., osteoarthritis) that limit their ability to perform ADLs, are in most need of training programs to improve their physical function. Therefore, it is of the utmost importance to design functional exercise programs aimed at improving performance of ADLs in dysfunctional elderly adults.

It has been suggested that exercise programs that incorporate functional exercises have proven beneficial in healthy, independent older and elderly adults; however, it is unknown if a functional exercise program using a suspension trainer can improve the functionality in a dysfunctional elderly population. The purpose of this study was to determine if functional exercise training, using the TRX suspension trainer, improves physical function and performance in ADLs in an institutionalized, physically dysfunctional elderly population.

Chapter 2. Review of Literature

This literature review will explore different types of exercise modalities, such as traditional resistance, power, balance, and functional training, used to demonstrate improvements in strength, endurance, and balance in older and/or elderly populations. While muscular strength and endurance are especially important in an elderly population, functional exercise training programs that elicit improvements in physical function and the ability to perform ADLs may provide the most benefit on quality of life. Studies have investigated functional training in highly functioning older and elderly adults who are not limited in their ability to perform ADLs; however, little is known if a functional exercise program using a suspension trainer can improve physical function in a dysfunctional elderly population.

Traditional Resistance Training

Several modalities of traditional resistance training, such as high and low intensity free weight exercises (Seynnes et al., 2004), and high intensity weight-machine programs (Fiatarone et al., 1994) have shown to provide physical benefits in the elderly population.

Fiatarone et al. (1994) studied the effects of traditional, progressive, high-intensity (80% of 1 repetition maximum) strength training in a frail, institutionalized, elderly population. Subjects trained only knee and hip extensor muscles with weight machines. Fiatarone et al. (1994) chose to train the knee and hip extensor muscles due to their major role they have in performing ADLs. Exercise sessions occurred 3 days per week for a total of 10 weeks. The training program demonstrated statistically significant increases in muscular strength and cross-sectional area, and increases in daily physical activity.

A 10-week, traditional strength training program was used in pre-frail elderly women (Lustosa et al., 2011). Participants in this study used lower body exercises with ankle weights and the participant's body weight as resistance. Results showed statistically significant increases in lower-body strength and improvements in functional capacity, as measured by the Timed Get Up and Go test.

Research has demonstrated that these modalities improve strength and physical function in the elderly, but a dysfunctional, institutionalized elderly population may not benefit from traditional strength training modalities. All of these methods of resistance training require expensive and relatively stationary equipment that may not be safe for a frail, dysfunctional elderly population. Also, those dysfunctional elderly that are in a nursing home or assisted living facility may not have the exercise equipment to allow residents to participate in resistance training. Therefore, more research needs to be done on safe, simple equipment that can improve physical function and the ability to perform ADLs in the elderly.

Power Training

Power training (exercises that work to improve strength and speed simultaneously) has also been used to increase functionality in elderly adults (Pereira et al., 2012). In a meta-analysis on research articles comparing power training to strength training in elderly adults, it was concluded that power training exhibited only slightly more benefits in functionality than traditional strength training (Tschopp, Sattelmayer, & Hilfiker, 2011); however, all participants in these studies were non-frail individuals with no functional limitations. While power training demonstrated “a small advantage over strength training” for increases in

functionality, it was noted that the safety of the type of training might not be suitable for all older populations (Tschopp et al., 2011).

Power training was also compared to traditional strength training in a dysfunctional elderly population. Results showed similar improvements in both training groups when compared to the control group (Reid, Callahan, Carabello, Phillips, Frontera, & Fielding, 2008). While this study showed both power and strength training may be used in a dysfunctional elderly population, the subjects were not institutionalized and, therefore, were able to function well enough to live independently. In an institutionalized, dysfunctional elderly population, power training may not be the safest option for increasing functionality.

Balance Training

Balance training programs could be helpful to decrease falls risk in a dysfunctional elderly population, but there is much less research on this type of training and therefore not a clear protocol that can be used to accomplish specific training effects, especially when using balance training as the sole mode of exercise (Granacher, Muehlbauer, Zahner, Gollhofer, & Kressig, 2011). Muhlberg and Sieber (2004) recommend continuous neuromuscular and balance training and mobilization, however there are no recommendations as to how that type of program should be designed. In order to improve functionality, mobility must be improved, which involves dynamic balance. Based on their systemic review of balance training programs in healthy adults, DiStefano, Clark, and Padua (2009) suggest that balance training performed over 4 weeks, 10 minutes a day, 3 days per week will yield improvements in balance.

Specifically in a less functional population, combining balance training with resistance training may yield more benefits in an elderly population. Community-dwelling elderly women with a history of recent falls improved strength and balance and decreased fall risk after 6 months of a combined balance- and resistance-training program (Beyer et al., 2007).

Balance is an important aspect of the functional STS task (Lord et al., 2002). Lord et al. (2002) demonstrated that improved balance can independently improve the STS action. Therefore, incorporating multiple training methods, including balance, into an exercise program for institutionalized elderly may be the most effective way to improve functionality.

Functional Training

Exercise programs that are used in the elderly population usually have the overarching goal of improving quality of life and functionality. Many exercise program interventions tend to isolate muscle groups (i.e., quadriceps, hamstrings, etc.), but few incorporate multi-joint ADLs into the program. In a realistic situation, the ability to stand up from a chair or toilet is more useful than being able to perform a leg extension. It has been proven that exercise programs combining multiple aspects of training, such as strength and balance, provide better results in improving functionality in the elderly (Hunter, McCarthy, & Bamman, 2004).

One study compared the effects of a functional training program to a traditional resistance training program on performing ADLs in a healthy, older female population (De Vreede, Samson, Van Meeteren, Duursma, & Verhaar, 2005). Their results indicate that the

functional training program was more effective than the traditional strength training program on improving ability to perform ADLs, even after a 6-month detraining period.

Another study, by Manini et al. (2007), compared functional exercise training to a resistance training program and a combined program of traditional resistance and functional exercise training. The subjects in this study were older adults who needed to make modifications to ADLs in order to perform them independently. Exercises used in the functional training group included chair squats, rising from a kneeling position, stair climbing, vacuuming, and lifting and carrying a laundry basket. The functional exercise training group showed the most improvements ability to complete ADLs, whereas the resistance training group showed the least amount of improvements in ability to complete ADLs. This study shows that functional exercise training may help to improve functionality in an older or elderly population, more so than a traditional strength training program.

Another form of functional training that is different from other forms of resistance training is suspension training, such as the TRX suspension trainer. Suspension training involves using one's body weight as resistance while holding onto handles that are anchored to a stationary support (i.e., door, wall, etc.). The suspension trainer offers unique benefits because it is portable, lightweight, and costs much less than traditional strength training equipment. The suspension trainer can be used in a variety of places, and is totally individualized via simple adjustments to the length of the straps. Traditionally, suspension trainers have been used as an exercise device in an athletic population because they challenge one's balance, strength, power, and agility. However, suspension training may offer benefits to the elderly population, but there is currently no scientific literature on using suspension trainers in any population.

Conclusion

While evidence exists that demonstrates various modalities of resistance training improve strength and physical function in highly functioning elderly populations, but much less is known about these modalities in limited-function or dysfunctional elderly populations. Functional training improves physical function and balance in the elderly, but it is unknown if functional training, utilizing a suspension trainer, will improve functionality in institutionalized, dysfunctional elderly individuals.

Chapter 3. Methods

Subjects

Subjects were recruited from Deerfield Ridge Assisted Living in Boone, North Carolina. Inclusion criteria included being 65 years of age or older and having difficulty with standing up from a chair independently. Exclusion criteria included having cognitive, emotional, or psychological issues, and/or having an orthopedic injury or surgery within the last year. Upon signing an informed consent form, each subject's physician signed a medical clearance form stating their patient had no health concerns that would prevent them from participating in the functional testing or exercise program.

Initially, eight subjects consented to participating in the study and were approved by their physicians. After the pre-program testing, four participants dropped out of the study. After three weeks of exercise, one participant had an unrelated injury, which prevented her from continuing on in the study. Therefore, three participants completed the full 8-week functional exercise training program and three functional testing sessions.

Functional Testing

Subjects performed the functional testing a total of three times: before the exercise program started (pre), after 4 weeks of exercise (4 weeks), and after 8 weeks of exercise (post). The subjects performed the following functional tests at each of the three time points. To control for inter-administrator variance, the same researcher administered the functional tests at each of the three time points for the same subject.

Handgrip Strength

The subject became familiarized with the dynamometer before testing. While seated in a straight back chair, the subjects held the dynamometer with their elbow at 90°, forearm in a neutral position, and the wrist between 0-30° of extension. The subject was instructed to squeeze the dynamometer as forcefully as possible for 3 seconds. The same procedure was used for 3 attempts on each hand, alternating between hands with a rest period of 20 seconds between trials. The best of 3 trials for each hand was taken. All measurements were recorded in kilograms.

5 Timed Repeated Sit-to-Stand

Subjects were seated in an arm chair (height = 46 cm) with their back flat against the chair and both feet flat on the floor. The subject was instructed to stand up and sit down five times as quickly as possible. The subject was encouraged to not use the arms of the chair, if possible. If able to stand without using the arms of the chair, the subject was instructed to cross their arms across their chest. The subject was timed beginning from the tester saying “go,” until the participant completed the fifth sit-to-stand and was in the final seated position.

Timed Up and Go Test

An arm chair (height = 46 cm) was used as the starting point. From the front of the chair a distance of three meters was measured and marked with a line of tape. The subjects were able to use their assistive device, if needed. The subject was instructed to stand up and walk as quickly as possible to the line on the floor, turn around, walk back to the chair, and

sit down again. The test administrator demonstrated the test for the subject. The test was timed from the test administrator saying “go,” until the subject was seated back in the chair.

Berg Balance Test

Individual instructions for each test were read to the subject before completing the individual tasks. A point value from 0-4 was assigned for each of the 14 sub-tests, with a score of “0” indicating the lowest level of function and a score of “4” indicating the highest level of function. The sub-test scores were summed, giving the subject a total score from 0-56. The sub-test included the following: sit-to-stand, standing unsupported, sitting unsupported, stand-to-sit, transfers, standing with eyes closed, standing with feet together, reaching forward, retrieving an object from the floor, looking behind, 360° turn, placing a foot on a foot stool, standing with feet in tandem, and single leg balance. Based on the results from Lajoie & Gallagher (2004), a total score less than 46 indicates a fall risk in the elderly population.

SF-36 Survey

The Short Form-36 (SF-36) survey is a 36 question multipurpose survey that generates physical and mental component profile scores for eight individual categories: Physical Function, Role-Physical, Bodily Pain, General Health, Vitality, Social Function, Role-Emotional, and Mental Health (Ware & Gandek, 1998). Each category is transformed to a score from 0 to 100 and is given equal weight, with the total score also ranging from 0 to 100. Lower scores indicate a lower level of quality of life.

The physical component is most strongly correlated to the categories of Physical Functioning, Role-Physical, and Bodily Pain (Ware & Gandek, 1998). The mental component is most strongly correlated to the categories of Mental Health, Role-Emotional, and Social Functioning (Ware & Gandek, 1998). The categories of Vitality, General Health, and Social Functioning are strongly correlated to both the mental and physical components (Ware & Gandek, 1998). The survey administrators assisted the subjects with the survey as each question and possible answers were read to the subjects and explained for clarity, if needed. The surveys were scored using *ScottCare* software (ScottCare Cardiovascular Solutions, Cleveland, Ohio).

Exercise Intervention

For all functional training sessions, participants used the TRX suspension trainer hooked to an anchor on the wall (approximately two meters high). The functional training sessions occurred three times per week for a total of eight weeks (24 total training sessions). Each training session included the following six exercises:

- *Modified Squat* – While sitting in a chair holding the handles of the TRX, participants stood up and sat back down with the assistance of the TRX.
- *Hip Press* - While standing and holding the TRX handles with their arms extended, participants pulled themselves towards the anchor, pressing their hips forward to focus on squeezing the buttocks.
- *Single leg balance* – While standing and holding the TRX handles, participants shifted their weight to one leg, trying to balance, then return to standing on both feet. This motion was repeated with the opposite leg.

- *Heel and Toe Raises* – While standing and holding the TRX handles, subjects pressed their toes down to raise the heels off the floor as high as possible, then return to flat. Next, they lifted their toes off the floor to balance on the heels, then return to flat.
- *Shoulder mobility* – While seated, subjects held the TRX handles (with the bands tight) straight out in front of them. They made large circular patterns with their hands, stopping at the top of the circle for 4 seconds, then returned to the starting position.
- *Modified Row* - While seated on the edge of their seat, both feet firmly planted on the floor, subjects held the TRX handles (with the bands tight) next to their chest. The subjects assumed a reclined position so that their arms were straight. Subjects pulled themselves up so that their backs were straight up, and then lowered themselves back to the reclined position.

The following table shows how the repetitions of the exercises were progressed through the 8 weeks:

Weeks 1 & 2	2 sets of 6 repetitions
Weeks 3 & 4	2 sets of 8 repetitions
Weeks 5 & 6	2 sets of 10 repetitions
Weeks 7 & 8	2 sets of 12 repetitions

Statistical Analysis

A one-way repeated analysis of variance test was performed for each outcome measure to test for significance between testing periods, using statistical software (Sigma Plot 12.0; Systat Software, Inc., San Jose, CA, USA). Outcome measures are reported as Mean \pm SD. Statistical significance was set at a *p-value* of $\alpha \leq 0.05$.

Chapter 4. Results

Handgrip Strength

Handgrip strength tended to be significant (Table 1) for the right ($p = 0.072$) and left hands ($p=0.090$) as a result of the 8-week functional training program. Right handgrip strength improved from pre- (16.8 ± 5.8) to 4-week (21.0 ± 9.5) testing, but appeared to decrease back to pre-testing levels at post-testing (16.3 ± 8.0). The dominant hand for all three subjects was the right hand. Left handgrip strength improved from pre- (18.3 ± 6.7) to 4-week (19.8 ± 6.8) testing, but decreased below pre-testing levels at post-testing (15.5 ± 8.2).

5 Timed Repeated Sit-to-Stand

No significant differences were found between pre-, 4-week, and post-testing periods ($p=0.856$) in the 5 timed repeated sit-to-stand task (Table 2). Average time to complete 5 sit-to-stand repetitions appeared to increase from pre- (14.4 ± 14.5) to 4-week (23.3 ± 28.4) testing, and remained similar at post-testing (22.8 ± 12.0). Of note, during the pre- and 4-week testing sessions, only two subjects were able to complete the test, while all three subjects were able to attempt the test during post-testing.

Timed Up and Go

No significant differences were found in the timed up and go task between pre-, 4-week, and post-testing periods ($p=0.430$; Table 3). During pre-testing, two of the subjects were able to complete the test (24.3 ± 22.3), but at the 4-week (9.8 ± 16.9) and post-testing

(9.2±15.9), only subject one was able to complete the test, during which her time improved from 29.3 seconds to 27.5 seconds.

Berg Balance Scale

There were no significant differences found for the total Berg Balance Score between pre-, 4-week, and post-testing periods (end of Table 4; $p=0.806$). Total Berg Balance Scores (maximum function score of 56) appeared to decrease from pre- (22.7±17.2) to 4-week (16.0±12.1) testing, but then appeared to increase back to pre-testing levels at post-testing (21.0±18.2). As for the individual sub-tests in the Berg Balance Scale (score of “0” indicating the lowest level of function and a score of “4” indicating the highest level of function), there was a significant main effect of treatment on the *Sit-to-Stand* task ($p=0.033$); revealing a significant difference between the 4-week testing period (1.0±1.0) and the post-testing period (3.0±1.0; $p=0.039$), but not the pre-testing period (2.0±1.7). There were no significant treatment effects for any of the other sub-tests in the Berg Balance Scale between pre-, 4-week, and post-testing periods (Table 4). Details on the non-significant individual sub-tests in the Berg Balance Scale are reported below.

Stand Unsupported

Scores decreased from pre- (2.0±1.7) to 4-week (0.7±1.2) testing, and increased during post-testing (1.3±2.3). $P\text{-value} = 0.444$.

Sit Unsupported

Scores increased from pre- (3.7±0.6) to 4-week (4.0±0.0) testing and remained the same at post-testing (4.0±0.0). $P\text{-value} = 0.444$.

Stand-to-sit

Scores increased from pre- (2.7 ± 1.5) to 4-week (3.0 ± 0.0) testing, and slightly increased at post-testing (3.3 ± 0.6). *P-value* = 0.694.

Transfers

Scores decreased from pre- (2.3 ± 2.1) to 4-week (1.7 ± 1.2) testing, and remained the same at post-testing (1.7 ± 2.1). *P-value* = 0.830.

Standing with eyes closed

Scores decreased from pre- (2.3 ± 2.1) to 4-week (1.3 ± 2.3) testing, and remained the same at post-testing (1.3 ± 2.3). *P-value* = 0.678.

Standing with feet together

Scores decreased from pre- (2.3 ± 2.1) to 4-week (0.7 ± 1.2) testing. Scores increased at post-testing (1.3 ± 2.3). *P-value* = 0.444. Subject 1 was the only subject able to complete this task during pre-, 4-week, and post-testing.

Reach forward

Scores decreased from pre- (1.0 ± 1.7) to 4-week (0.0 ± 0.0) testing, and increased at post-testing (1.3 ± 2.3). *P-value* = 0.683.

Retrieve an object from the floor

Scores decreased from pre- (2.0 ± 1.7) to 4-week (1.0 ± 1.7) testing and remained the same at post-testing (1.0 ± 1.7). *P-value* = 0.444.

Look behind

Scores increased from pre- (0.7 ± 0.6) to 4-week (1.7 ± 2.1) testing and remained the same at post-testing (1.7 ± 2.1). *P-value* = 0.529.

360° turn

Scores decreased from pre- (0.7 ± 1.2) to 4-week (0.0 ± 0.0) testing, and increased at post-testing (0.3 ± 0.6). *P-value* = 0.640.

Place foot on footstool

Scores decreased from pre- (0.7 ± 1.2) to 4-week (0.0 ± 0.0) testing, and increased at post-testing (0.7 ± 1.2). *P-value* = 0.694.

Standing with feet in tandem

Scores increased from pre- (0.3 ± 0.6) to 4-week (1.0 ± 1.7) testing, and decreased at post-testing (0.0 ± 0.0). *P-value* = 0.588.

Single leg balance

Scores remained the same during pre-, 4-week, and post-testing (0.0 ± 0.0 , respectively). *P-value*: N/A.

SF-36 Survey

No significant differences were found for any of the eight categories of the SF-36 Survey between pre-, 4-week, and post-testing periods (Table 5). Details on the individual categories in the SF-36 Survey are reported below. Lower scores indicate a lower level of quality of life.

Physical Function

Scores increased from pre- (19.15 ± 5.57) to 4-week (21.26 ± 6.32) and post-testing (25.47 ± 11.13). *P-value* = 0.173.

Role Physical

Scores increased from pre- (30.73±5.65) to 4-week (37.26±16.96) and post-testing (46.24±11.04). *P-value* = 0.299.

Bodily Pain

Scores increased from pre- (37.33±7.20) to 4-week (40.14±19.04) and post-testing (45.64±14.83). *P-value* = 0.363.

General Health

Scores increased from pre- (45.35±13.59) to 4-week (45.15±5.25) and post-testing (48.96±4.96). *P-value* = 0.541.

Vitality

Scores decreased from pre- (45.85±6.25) to 4-week (42.72±3.13) and increased at post-testing (50.01±1.80). *P-value* = 0.276.

Social Function

Scores increased from pre- (40.49±14.43) to 4-week (51.40±9.45) and decreased at post-testing (47.76±15.74). *P-value* = 0.284.

Role Emotional

Scores increased from pre- (39.03±17.53) to 4-week (42.92±11.87) and post-testing (49.40±11.22). *P-value* = 0.191.

Mental Health

Scores increased from pre- (53.76±3.25) to 4-week (55.64±4.88) and decreased at post-testing (53.76±10.66). *P-value* = 0.805.

Chapter 5. Discussion

This study investigated whether specific functional exercise training, using the TRX suspension system, would improve physical function and performance in an elderly, dysfunctional population. The exercise training sessions were held three days per week for eight weeks, resulting in a total of 24 sessions. The goal of the exercises chosen was to improve balance, strength, and ability to perform activities of daily living. The repetitions for each exercise were increased by two every two weeks to provide a progressive exercise stimulus. Functional testing sessions occurred before the exercise program started, after 4 weeks of exercise, and at the end of 8 weeks.

As reported in the results, only one of the outcome measures tested, the Sit-to-Stand task, demonstrated a statistically significant treatment effect across the training period. This result indicates that the functional exercise training program, using the TRX suspension trainer, improved the subject's ability to perform the sit-to-stand task in the latter portion of the training program. Our inability to detect significant treatment effects in any other outcome measure for this study was primarily due to the low subject population, as only three subjects completed the entire 8-week functional exercise training and all three testing sessions. Therefore, each subject's characteristics, compliance, and outcome measures are discussed individually below, followed by a general discussion of the outcome measures.

Subject 1

Subject Characteristics

Subject 1 was a physically dysfunctional 74-year old female who had other co-morbidities, including Type 2 diabetes mellitus, osteoarthritis in her hips and knees, obesity, and Chronic Obstructive Pulmonary Disease (COPD). She was a current smoker who had smoked for at least the past 30 years. This subject had also spent the majority of the last 20 years in a wheelchair because of chronic joint pain caused by injuries sustained in a car accident. Before beginning the functional training program, the only times that this subject got out of her wheelchair was to go to the bathroom and bathing herself.

Subject Compliance

Subject 1 completed nearly 80% of the functional exercise training sessions (19 out of 24). She chose not to make up any of her absences. Despite missing five exercise sessions, she was able to complete all repetitions of all the exercises and progress with increasing repetitions bi-weekly.

Handgrip strength

The left handgrip strength progressively declined (pre=24; 4-week=23; post=20) over the 8 weeks of training, while the right handgrip strength increased at 4 weeks and then declined below pre-testing measures (pre=18; 4-week=22; post=17).

5-Timed Repeated Sit-to-Stand

At the pre- and 4-week testing sessions, this subject was unable to stand without the use of her hands. This limited her in various ways, such as being in a location that has a toilet without handles to use to stand up unassisted. It also limited her by forcing her to rely on her

arms during exercise, allowing disuse and atrophy of her lower limb muscles. While her sit-to-stand time increased from 15 seconds to 20 seconds between her 4-week and post-testing, she was able to stand without the use of her hands.

Timed Up and Go

Subject 1 decreased the time to complete this test from pre-testing (29.13 seconds) to post-testing (27.5 seconds). She used a wheeling walker for pre-, 4-week, and post-testing

Berg Balance

This subject progressively improved her total Berg Balance score, improving by 16 points from pre-testing (26) to post-testing (42). At both pre- and 4-week testing periods, the subject was afraid to try some of the sub-tests, such as placing one foot on the footstool and completing a 360° turn. After 8 weeks of training, the subject was able to attempt these tests, but still not fully functional.

SF – 36

All categories of the physical health component and mental health component scores improved from pre-testing to post-testing in Subject 1. The largest improvement occurred in the Social Function category by 21.82.

Subject 2

Subject Characteristics

Subject 2 was an 86-year old female with severe osteoarthritis in her knees. This subject had remained in a wheelchair for the past 2 years and emphasized that she is most comfortable when sitting. This subject's osteoarthritic knee pain prevented her from remaining standing for more than a few seconds at a time.

Subject Compliance

This subject completed 92% of the functional exercise training sessions (22 out of 24). Throughout the 8-week training period, she was not able to remain standing for more than a few seconds and therefore could not complete the single leg balance or the heel and toe raise exercises. The single leg balance exercise was omitted and the heel and toe raise exercise was modified so that she could complete it in a seated position. While seated, she lifted her feet off of the ground and plantar- and dorsi-flexed her feet. She held an isometric contraction in each position for a few seconds. The time of the isometric hold and number of reps she completed matched the same progression as the other exercises. For example, during weeks 1 and 2, she held each position for 6 seconds, and completed six repetitions in each position; during weeks 3 and 4, she held each position for 8 seconds and completed eight repetitions in each position; and so on. She was able to complete all of the repetitions for all other functional exercises throughout the 8-week training period.

Handgrip strength

This subject's handgrip strength from pre- (right =10.5 kg; left =11 kg) to 4-week (right =11 kg; left =12 kg) testing but declined below pre-testing values at post-testing (right =8 kg; left =6 kg).

5-Timed Repeated Sit-to-Stand

At pre-testing, the subject did not want to attempt to stand, but at 4-weeks, she was able to complete five sit-to-stands within 55 seconds with the use of the chair arms. She also requested having multiple people near her due to her fear of falling, but required no assistance performing the test. At post-testing, she completed five repetitions in 36 seconds

and requested to complete them without help from other people since she was confident she could do them alone. Her ability to stand independently and repeatedly will help her to gain some independence since she was unable to use the bathroom without people assisting her.

Timed Up and Go

This subject was unable to perform this task at any of the testing periods.

Berg Balance Test

Subject 2 progressively increased her Berg Balance scores throughout from pre-testing to post-testing. Specifically, this subject was unable to transfer herself without the help of two people at pre-testing; however, by the end of the 8-week training period, she was able to transfer with the help of only one other person. At pre-testing, the subject was unable to perform the stand to sit test without assistance. She progressed to sitting independently, which has helped her to become more independent. As reflected in the improved sit-to-stand time, she was able to improve her score in the Berg Balance test.

SF-36

The Role Physical, and Bodily Pain categories of the SF-36 improved by 29.38 and 16.48 points, respectively, in the physical health component. While the Mental Health category improved, Social Function and Role Emotional remained the same, and General Health and Vitality declined in the mental health component for Subject 2.

Subject 3

Subject Characteristics

Subject 3 was an 84-year old male who presented with weakness and pain in his lower extremities due to osteoarthritis. While he started the study as the highest functioning

subject, he required the assistance of a walker for balance when walking, but was not using a wheel chair. Due to injuries and other health problems that occurred during the time frame of the study (unrelated to his participation in the study), this subject's functionality declined quickly from his pre-testing period. These setbacks forced him to remain in a wheelchair and thus, unfortunately, he did not improve from his initial functionality level.

Subject Compliance

Despite his decline in his health and physical function, this subject still completed 92% of the functional exercise training sessions (22 out of 24). During week 3, he began having difficulty with the exercises but was still able to complete all of the repetitions. During weeks 4 and 5, this subject was unable to complete the modified squat, single leg balance, and heel and toe raises. During weeks 6 and 7, he started performing the modified squat again, with two sets of four repetitions. During week 8, this subject increased the modified squat to two sets of six repetitions. During weeks 4 and 5, this subject was unable to complete the heel and toe raises. During week 6, he was able to perform the modified heel and toe raises, similar to subject 2, he performed this exercise by dorsi- and plantar-flexing the feet while seated. He began with two sets of six during week 6 and progressed to two sets of eight during weeks 7 and 8. This subject was unable to perform the single leg balance exercise from weeks 4 through 8.

Handgrip Strength

Subject 3 improved his handgrip strength from the pre- (right =22 kg; left =20 kg) to the 4-week (right =30 kg; left =24.5 kg) testing period, but then declined post-testing (right =24 kg; left =20.5 kg).

5-Timed Repeated Sit-to-Stand

At pre-testing, subject 3 was able to complete five repetitions in 28.9 seconds. After 4 weeks of exercise, this subject had declined so much that he was unable to complete any sit-to-stand repetitions independently. However, by post-testing, the subject was able to complete three repetitions in 12.5 seconds before becoming too fatigued to continue.

Timed Up and Go

Subject 3 was only able to complete this test during the pre-test (43.8 seconds), but was unable to complete the Timed Up and Go during the 4-week and post-testing.

Berg Balance Test

Subject 3 scored highest during the first testing session (38), declined severely at the 4-week (9) and post-testing (10) periods. From pre- to 4-week testing, the subject declined in the sit-to-stand from a score of 3 to 1. However, at post-testing, the subject had improved back to a score of 3. While his 5-Timed Repeated Sit-to-Stand performance decreased, he was still able to stand independently.

SF-36

Surprisingly, all categories of the physical health component, except Vitality, improved over the 8-week training period in Subject 3, despite drastic declines in his physical health. His mental health component scores varied from pre- to post-testing. Mental Health and Vitality decreased, Social Function did not change, and Role Emotional increased from pre- to post-testing.

Outcome Measures Discussion

Handgrip Strength

Handgrip strength has been shown to be a simple assessment of total body muscular strength (Roberts et al., 2011) and an accurate predictor of all-cause mortality in an elderly population (Sasaki, Kasagi, Yamada, & Fujita, 2007). The TRX suspension trainer is a unique mode of exercise because it requires the participant to use their hands to support them during the functional exercises. Theoretically, handgrip strengths should have improved after 8 weeks of functional training with the TRX, but we did not observe any significant increases in handgrip strength over the 8-week training period. The presence of diseases including COPD, diabetes mellitus, osteoarthritis, and atherosclerotic cardiovascular disease can decrease overall muscular strength due to several factors including inflammation, malnutrition and sedentary lifestyle (Rantanen et al., 1998). In a 27-year longitudinal study, diabetes, arthritis, and coronary artery disease were all associated with very low (≤ 21 kg) handgrip strengths (Rantanen et al., 2003). Therefore, despite this 8-week training study, a longer duration program may have been required to significantly increase strength, and, consequently, handgrip strength.

Berg Balance Scale

The Berg Balance Scale was specifically designed for measuring functional balance and falls risk in an elderly population (Muir, Berg, Chesworth, & Speechley, 2008). Decreased balance puts elderly individuals at an increased risk for falls (Muir et al., 2008). A change of 8 points in total Berg Balance Scale scores between assessments is necessary to

determine a true change in function in an elderly population no longer living independently (Conradsson et al., 2007).

Subject 1 yielded an increase in 16 points from pre to post testing, indicating that she had a true improvement in function. Subject 2 yielded an increase of 7 points which, according to results from Conradsson et al. (2007), is not a large enough increase in points to indicate a true improvement in function. However, her improvement in function may have been great enough to improve her quality of life and performance of ADLs. Subject 3 had a decrease of 28 points from pre- to post-testing, indicating he had a true deterioration in function, according to these criteria.

Timed Repeated Sit-to-Stand

In this study we used the Sit-to-Stand (STS) test, which is included in the Berg Balance Scale, and the Timed Repeated Sit-to-Stand test as benchmark functional tests to determine physical function and ability to perform ADLs independently. We observed a significant increase in the STS task from the 4-week to the post-testing period. The STS movement can be influenced by various factors such as balance, reaction time, strength, vision, mobility, and peripheral sensations (Lord et al., 2002). The STS movement can also be affected by perception of pain and depression (Lord et al., 2002). All three subjects complained of lower limb weakness and pain at the start of the study, which possibly influenced any of the functional tests that used the STS movement. While strength and balance could have been improved through the 8-week training intervention, pain management wasn't taken into consideration in this study. The STS movement is also affected by subject motivation (Lord et al., 2002). All three subjects were dependent upon

wheelchairs at the start of the program. Although a goal of the study was to improve their functionality, due to the frailty of the subjects, it was not expected that the functionality of the subjects' would improve so greatly that they would be able to stop using their wheelchairs. Furthermore, by being in an assisted living facility, the subjects' had help from staff to complete ADLs which may have decreased motivation to perform the STS movement independently.

SF-36 Survey

The SF-36 survey is a questionnaire used to measure health-related quality of life. It is separated into 8 different categories: Physical Functioning, Role Physical, Role Emotional, Bodily Pain, Social Functioning, Mental Health, Vitality, and General Health. The categories are grouped by physical or mental components (Cleary & Howell, 2006). Studies have shown that the Mental Health category and Physical Functioning category are the most valid representations of overall mental health and physical health, respectively (Ware & Gandek, 1998).

The physical component includes Physical Functioning, Role Physical, Bodily Pain, General Health, and Vitality. The Physical Functioning category determines if there is a limitation in completing ADLs. The Role Physical category determines how much one's physical health interferes with daily activities. The Bodily Pain category determines how much one's pain interferes with ADLs. The General Health category determines what positive or negative changes in physical health have occurred over the last year. The Vitality category determines one's energy levels (Cleary & Howell, 2006).

The mental component includes Role Emotional, Social Functioning, Mental Health,

Vitality, and General Health. The Role Emotional category determines how much one's emotional health interferes with daily activities. The Social Functioning category determines the impact of physical and emotional health on social activities. The Mental Health category determines how often one is anxious, nervous, happy, and depressed (Cleary & Howell, 2006).

A low Physical Functioning category score has been shown to be related to lower handgrip strength, and longer times in the Timed Up and Go test and Timed Repeated STS test in both men and women (Syddall, Martin, Harwood, Cooper, & Aihie Sayer, 2009). All three subjects scored below the 25th percentile for their gender during pre-, 4-week, and post-testing periods (Ware, Kosinski, Dewey, & Gandek, 2000). This may indicate that the subjects perceived they were limited in ADLs by their poor physical function; however, the general trend from pre- to post-testing was an increase in the mental and physical health component scores.

Limitations

This study had several limitations including subject number, lack of a control group, types of exercises performed, and volume of exercise. Due to the amount of subjects that dropped out of the study, the subject number was too low to detect significant changes in physical function. Furthermore, a control group may have helped to demonstrate that these subjects improved more than if they would have not participated in any exercise program.

The specific exercises chosen for the functional exercise training program in this study were chosen because the movements are used in ADLs. However subjects 2 and 3 were unable to perform some of the standing exercises. Perhaps other exercises that challenge the

neuromuscular system while seated should have been chosen to use with subjects unable to complete the standing exercises.

The volume (sets and repetitions) and intensity of exercise in this program may have been a limitation. Increasing the sets or repetitions might have helped to increase the physiological stimulus of the exercises. With the TRX suspension system, the ways to increase difficulty of the exercises are by increasing sets or repetitions, changing the length of the straps, and making the exercise more challenging (ex. decreasing base of support during the modified squat). Due to the frailty and initial poor physical function of this study population, changing the length of the straps and using more difficult exercises may not be appropriate. Some studies suggest that 2-3 days per week of strength training with three sets of 8-12 repetitions can yield improvements in strength and functional capacity in a frail, elderly population (Cadore, Rodriguez-Manas, Sinclair, & Izquierdo, 2013; Krist, Dimeo, & Keil, 2013). Therefore, using three sets as opposed to two, and starting the training with eight repetitions at week 1 may have helped to increase strength and functionality at a higher rate.

Conclusion

The purpose of this study was to determine if an 8-week functional exercise program, using the TRX suspension system, would improve physical function and performance in ADLs in a dysfunctional, elderly population. With the exception of the Sit-to-Stand task in the Berg Balance Scale, no significant differences were observed in any of the outcome measures at pre-, 4-week, and post-testing. The inability to detect improvements in physical function and performance in ADLs was most likely limited by the low subject numbers in this study.

After the 8 weeks of training, all three subjects indicated having definite plans to continue performing some type of strength training. Based on the results from the SF-36 survey, the perception of physical health had improved over the 8-week functional training period, despite no statistically significant improvements in functionality scores. Without participating in this study, these three individuals may have remained sedentary and continued to decline further. While most of the results were not statistically significant, these findings suggest that there may be a clinically important relevance for using the TRX suspension training system to improve physical function and quality of life in dysfunctional, elderly adults, if performed in larger groups of subjects. All three subjects were able to perform some of the ADLs better and with more independence than they previously could before the 8-week functional training program. Further research should explore the use of the TRX suspension training system with a larger volume of exercise, more exercises, and a control group.

Table 1. Handgrip Strength							
Right Hand (kg)*				Left Hand (kg)			
	Pre	4-week	Post		Pre	4-week	Post
Subject 1	18	22	17	Subject 1	24	23	20
Subject 2	10.5	11	8	Subject 2	11	12	6
Subject 3	22	30	24	Subject 3	20	24.5	20.5
Ave. \pm SD	16.8 \pm 5.8	21.0 \pm 9.5	16.3 \pm 8.0	Ave. \pm SD	18.3 \pm 6.7	19.8 \pm 6.8	15.5 \pm 8.2
P-value	0.072			P-value	0.090		

*Dominant hand for all subjects.

Table 2. Five-Timed Repeated Sit-to-Stand			
Time (sec)			
	Pre	4-week	Post
Subject 1	14.4	15	20
Subject 2	0	55	36
Subject 3	28.9	0	12.5*
Ave. \pm SD	14.4 \pm 14.5	23.3 \pm 28.4	22.8 \pm 12.0
P-value	0.856		

* 3 repetitions completed

Table 3. Timed Up and Go			
Time (sec)			
	Pre	4-week	Post
Subject 1	29.1	29.3	27.5
Subject 2	0*	0*	0*
Subject 3	47.3	0*	0*
Ave. \pm SD	24.3 \pm 22.3	9.8 \pm 16.9	9.2 \pm 15.9
P-value	0.430		

* Subject unable to complete assessment

Table 4. Berge Balance Scale						
Sit-to-Stand				Standing Unsupported		
	Pre	4-week	Post	Pre	4-week	Post
Subject 1	3	2	4	3	2	4
Subject 2	0	0	2	0	0	0
Subject 3	3	1	3	3	0	0
Ave.±SD	2.0±1.7	1.0±1.0	3.0±1.0	2.0±1.7	0.7±1.2	1.3±2.3
P-value	0.033			0.444		
Stand-to-Sit				Transfers		
	Pre	4-week	Post	Pre	4-week	Post
Subject 1	3	3	4	3	3	4
Subject 2	1	3	3	0	1	1
Subject 3	4	3	3	4	1	0
Ave.±SD	2.7±1.5	3.0±0.0	3.3±0.6	2.3±2.1	1.7±1.2	1.7±2.1
P-value	0.694			0.830		
Standing Feet Together				Reach Forward		
	Pre	4-week	Post	Pre	4-week	Post
Subject 1	3	2	4	0	0	4
Subject 2	0	0	0	0	0	0
Subject 3	4	0	0	3	0	0
Ave.±SD	2.3±2.1	0.7±1.12	1.3±2.3	1.0±1.7	0.0±0.0	1.3±2.3
P-value	0.444			0.683		
Look Behind				360° Turn		
	Pre	4-week	Post	Pre	4-week	Post
Subject 1	1	4	4	0	0	1
Subject 2	0	1	1	0	0	0
Subject 3	1	0	0	2	0	0
Ave.±SD	0.7±0.67	1.7±2.1	1.7±2.1	0.7±1.2	0.0±0.0	0.3±0.6
P-value	0.444			0.529		

Table 4 con't. Berg Balance Scale						
	Standing with Feet in Tandem			Single Leg Balance		
	Pre	4-week	Post	Pre	4-week	Post
Subject 1	0	3	0	0	0	0
Subject 2	0	0	0	0	0	0
Subject 3	1	0	0	0	0	0
Ave.±SD	0.3±0.6	1.0±1.7	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0
P-value	0.588			N/A		
	Sit Unsupported			Standing Eyes Closed		
	Pre	4-week	Post	Pre	4-week	Post
Subject 1	4	4	4	3	4	4
Subject 2	3	4	4	0	0	0
Subject 3	4	4	4	4	0	0
Ave.±SD	3.7±0.6	4.0	4.0	2.3±2.1	1.3±2.3	1.3±2.3
P-value	0.444			0.678		
	Retrieve Object from Floor			Place Foot on Footstool		
	Pre	4-week	Post	Pre	4-week	Post
Subject 1	3	3	3	0	0	2
Subject 2	0	0	0	0	0	0
Subject 3	3	0	0	2	0	0
Ave.±SD	2.0±1.7	1.0±1.7	1.0±1.7	0.7±1.2	0.0±0.0	0.7±1.2
P-value	0.444			0.640		
	Total Score					
	Pre	4-week	Post			
Subject 1	26	30	42			
Subject 2	4	9	11			
Subject 3	38	9	10			
Ave.±SD	22.7±17.2	16.0±12.1	21.0±18.2			
P-value	0.806					

Table 5. SF-36 Survey						
	Physical Function			Role Physical		
	Pre	4-week	Post	Pre	4-week	Post
Subject 1	25.47	27.57	38.09	37.26	27.47	47.06
Subject 2	17.05	21.26	21.26	27.47	56.85	56.85
Subject 3	14.94	17.94	17.05	27.47	27.47	34.81
Ave.±SD	19.15±5.57	21.26±6.32	25.47±11.13	30.73±5.65	37.26±16.96	46.24±11.04
P-value	0.173			0.299		
	Bodily Pain			General Health		
	Pre	4-week	Post	Pre	4-week	Post
Subject 1	33.38	29.15	41.41	30.53	40.06	43.4
Subject 2	45.64	62.12	62.12	57.7	50.55	52.93
Subject 3	32.96	29.15	33.38	44.83	44.83	50.55
Ave.±SD	37.33±7.20	40.14±10.99	45.64±14.83	44.35±13.59	45.15±5.25	48.96±4.96
P-value	0.363			0.541		
	Vitality			Social Function		
	Pre	4-week	Post	Pre	4-week	Post
Subject 1	45.85	39.6	52.09	35.03	56.85	56.85
Subject 2	52.09	42.72	48.97	56.85	56.85	56.85
Subject 3	48.97	39.6	45.85	29.58	40.49	29.58
Ave.±SD	45.85±6.25	42.72±3.13	50.01±1.80	40.49±14.43	51.40±9.45	47.76±15.74
P-value	0.276			0.284		
	Role Emotional			Mental Health		
	Pre	4-week	Post	Pre	4-week	Post
Subject 1	40.33	40.33	55.88	55.64	58.46	58.46
Subject 2	55.88	55.88	55.88	55.64	58.46	61.27
Subject 3	20.89	32.56	36.44	50.01	50.01	41.56
Ave.±SD	39.03±17.53	42.92±11.87	49.40±11.22	53.76±3.25	55.64±4.88	53.76±10.66
P-value	0.191			0.805		

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Appendix A.

Standardized Physical Function Test Scoring Sheet

Subject #: _____

Date: _____

1. BERG BALANCE SCALE

See separate instruction sheet

2. HAND-GRIP STRENGTH TEST

Handle position: _____

Dominant Hand: _____

	Attempt #1	Attempt #2	Attempt #3
Right hand -	_____ (kg)	_____ (kg)	_____ (kg)
Left hand -	_____ (kg)	_____ (kg)	_____ (kg)

3. TIMED REPEATED CHAIR RISE x 5 (SIT-to-STAND)

Attempt #1 _____ (sec) Completed repetitions: _____

Attempt #2 _____ (sec) Completed repetitions: _____

4. TIMED UP AND GO TEST

Attempt #1 _____ (sec) Assistive device (if applicable): _____

Attempt #2 _____ (sec) Assistive device (if applicable): _____

Berg Balance Scale

Name: _____ Date: _____

Location: _____ Rater: _____

ITEM DESCRIPTION SCORE (0-4)

Sitting to standing _____

Standing unsupported _____

Sitting unsupported _____

Standing to sitting _____

Transfers _____

Standing with eyes closed _____

Standing with feet together _____

Reaching forward with outstretched arm _____

Retrieving object from floor _____

Turning to look behind _____

Turning 360 degrees _____

Placing alternate foot on stool _____

Standing with one foot in front _____

Standing on one foot _____

Total _____

GENERAL INSTRUCTIONS

Please document each task and/or give instructions as written. When scoring, please record the lowest response category that applies for each item. In most items, the subject is asked to maintain a given position for a specific time. Progressively more points are deducted if:

- the time or distance requirements are not met
- the subject's performance warrants supervision
- the subject touches an external support or receives assistance from the examiner

Subject should understand that they must maintain their balance while attempting the tasks. The choices of which leg to stand on or how far to reach are left to the subject. Poor judgment will adversely influence the performance and the scoring. Equipment required for testing is a stopwatch or watch with a second hand, and a ruler or other indicator of 2, 5, and 10 inches. Chairs used during testing should be a reasonable height. Either a step or a stool of average step height may be used for item # 12.

Berg Balance Scale

SITTING TO STANDING

INSTRUCTIONS: Please stand up. Try not to use your hand for support.

- () 4 able to stand without using hands and stabilize independently
- () 3 able to stand independently using hands
- () 2 able to stand using hands after several tries
- () 1 needs minimal aid to stand or stabilize
- () 0 needs moderate or maximal assist to stand

STANDING UNSUPPORTED

INSTRUCTIONS: Please stand for two minutes without holding on.

- () 4 able to stand safely for 2 minutes
- () 3 able to stand 2 minutes with supervision
- () 2 able to stand 30 seconds unsupported
- () 1 needs several tries to stand 30 seconds unsupported
- () 0 unable to stand 30 seconds unsupported

If a subject is able to stand 2 minutes unsupported, score full points for sitting unsupported. Proceed to item #4.

SITTING WITH BACK UNSUPPORTED BUT FEET SUPPORTED ON FLOOR OR ON A STOOL

INSTRUCTIONS: Please sit with arms folded for 2 minutes.

- () 4 able to sit safely and securely for 2 minutes
- () 3 able to sit 2 minutes under supervision
- () 2 able to sit 30 seconds
- () 1 able to sit 10 seconds
- () 0 unable to sit without support 10 seconds

STANDING TO SITTING

INSTRUCTIONS: Please sit down.

- () 4 sits safely with minimal use of hands
- () 3 controls descent by using hands
- () 2 uses back of legs against chair to control descent
- () 1 sits independently but has uncontrolled descent
- () 0 needs assist to sit

TRANSFERS

INSTRUCTIONS: Arrange chair(s) for pivot transfer. Ask subject to transfer one way toward a seat with armrests and one way

toward a seat without armrests. You may use two chairs (one with and one without armrests) or a bed and a chair.

- () 4 able to transfer safely with minor use of hands
- () 3 able to transfer safely definite need of hands
- () 2 able to transfer with verbal cuing and/or supervision
- () 1 needs one person to assist
- () 0 needs two people to assist or supervise to be safe

STANDING UNSUPPORTED WITH EYES CLOSED

INSTRUCTIONS: Please close your eyes and stand still for 10 seconds.

- () 4 able to stand 10 seconds safely
- () 3 able to stand 10 seconds with supervision
- () 2 able to stand 3 seconds
- () 1 unable to keep eyes closed 3 seconds but stays safely
- () 0 needs help to keep from falling

STANDING UNSUPPORTED WITH FEET TOGETHER

INSTRUCTIONS: Place your feet together and stand without holding on.

- () 4 able to place feet together independently and stand 1 minute safely
- () 3 able to place feet together independently and stand 1 minute with supervision
- () 2 able to place feet together independently but unable to hold for 30 seconds
- () 1 needs help to attain position but able to stand 15 seconds feet together
- () 0 needs help to attain position and unable to hold for 15 seconds

REACHING FORWARD WITH OUTSTRETCHED ARM WHILE STANDING

INSTRUCTIONS: Lift arm to 90 degrees. Stretch out your fingers and reach forward as far as you can. (Examiner places a ruler at the end of fingertips when arm is at 90 degrees. Fingers should not touch the ruler while reaching forward. The recorded measure is the distance forward that the fingers reach while the subject is in the most forward lean position. When possible, ask subject to use both arms when reaching to avoid rotation of the trunk.)

- () 4 can reach forward confidently 25 cm (10 inches)
- () 3 can reach forward 12 cm (5 inches)
- () 2 can reach forward 5 cm (2 inches)
- () 1 reaches forward but needs supervision
- () 0 loses balance while trying/requires external support

PICK UP OBJECT FROM THE FLOOR FROM A STANDING POSITION

INSTRUCTIONS: Pick up the shoe/slipper, which is in front of your feet.

- () 4 able to pick up slipper safely and easily
- () 3 able to pick up slipper but needs supervision
- () 2 unable to pick up but reaches 2-5 cm(1-2 inches) from slipper and keeps balance independently
- () 1 unable to pick up and needs supervision while trying
- () 0 unable to try/needs assist to keep from losing balance or falling

TURNING TO LOOK BEHIND OVER LEFT AND RIGHT SHOULDERS WHILE STANDING

INSTRUCTIONS: Turn to look directly behind you over toward the left shoulder. Repeat to the right. (Examiner may pick an object to look at directly behind the subject to encourage a better twist turn.)

- () 4 looks behind from both sides and weight shifts well
- () 3 looks behind one side only other side shows less weight shift
- () 2 turns sideways only but maintains balance
- () 1 needs supervision when turning
- () 0 needs assist to keep from losing balance or falling

TURN 360 DEGREES

INSTRUCTIONS: Turn completely around in a full circle. Pause. Then turn a full circle in the other direction.

- () 4 able to turn 360 degrees safely in 4 seconds or less
- () 3 able to turn 360 degrees safely one side only 4 seconds or less
- () 2 able to turn 360 degrees safely but slowly
- () 1 needs close supervision or verbal cuing
- () 0 needs assistance while turning

PLACE ALTERNATE FOOT ON STEP OR STOOL WHILE STANDING UNSUPPORTED

INSTRUCTIONS: Place each foot alternately on the step/stool. Continue until each foot has touched the step/stool four times.

- () 4 able to stand independently and safely and complete 8 steps in 20 seconds
- () 3 able to stand independently and complete 8 steps in > 20 seconds
- () 2 able to complete 4 steps without aid with supervision
- () 1 able to complete > 2 steps needs minimal assist
- () 0 needs assistance to keep from falling/unable to try

STANDING UNSUPPORTED ONE FOOT IN FRONT

INSTRUCTIONS: (DEMONSTRATE TO SUBJECT) Place one foot directly in front of the other. If you feel that you cannot place your foot directly in front, try to step far enough ahead that the heel of your forward foot is ahead of the toes of the other foot.

- () 4 able to place foot tandem independently and hold 30 seconds
- () 3 able to place foot ahead independently and hold 30 seconds
- () 2 able to take small step independently and hold 30 seconds
- () 1 needs help to step but can hold 15 seconds
- () 0 loses balance while stepping or standing

STANDING ON ONE LEG

INSTRUCTIONS: Stand on one leg as long as you can without holding on.

- () 4 able to lift leg independently and hold > 10 seconds
- () 3 able to lift leg independently and hold 5-10 seconds
- () 2 able to lift leg independently and hold L 3 seconds
- () 1 tries to lift leg unable to hold 3 seconds but remains standing independently.
- () 0 unable to try of needs assist to prevent fall

Vita

Amanda Kosmata was born in Garfield Heights, Ohio to Debbie and Terry Kosmata. In 2008, she enrolled in Ohio Wesleyan University, in Delaware, Ohio, and graduated in 2012. She received the degree of Bachelor of Arts and majored in exercise science and English literature. In 2012 she entered the Graduate School at Appalachian State University and studied within the Department of Health and Exercise Science. Her concentration was in clinical exercise physiology, and she became a certified Clinical Exercise Specialist through the American College of Sports Medicine. While at Appalachian State University, Amanda worked in the Appalachian Cardiopulmonary Rehabilitation Program.